pixels **254** each containing a number representative of infrared brightness at the corresponding point of the film **206**. The infrared memory array **252** contains the defects **256** but no image **214** because the three dyes that create an image **214** in film **206** are all transparent to infrared light. Each pixel **222** in the visible memory array **220** is divided by the corresponding pixel **254** in the infrared memory array **252** by function **258** to yield a corrected pixel **260** in the corrected image array **262**. This process is repeated for each color channel to produce the other color channels **264** and **266**, automatically yielding a defect free image **268** from the film.

As will be apparent in the general description, the process of infrared surface defect correction as taught in the prior art was not extendable to reflection scans. This was unfortunate because on average significantly more reflection scans are made as compared to transmission scans. A method of extending infrared surface defect correction to reflection scanning would be a major advance to the art of digital imaging.

FIG. **4** illustrates a further related art that is background to the current invention. In the context of surface defect correction, infrared brightness can be used to determine the percent attenuation attributable to a defect. For example, if the infrared record were attenuated from 100% with no defect to 90% with a defect present, and the visible record transmitted 9% with the defect present, obviously the visible record would have transmitted 10% without the defect. A common mistake is to subtract, rather than divide, the infrared record. In the example just given, the infrared transmission dropped from 100% to 90%, a change of −10%. If −10% is subtracted from the measured 9% visible transmission, the result is a 19% transmission, a gross overcorrection.

Nevertheless, it is often desirable to perform a surface defect correction as a subtraction rather than a division. For example, it may be desirable to perform the correction separately on separate frequency bands. Obviously, one cannot divide two cycles that average to zero with any image remaining; one must instead use the linearity of a subtraction. To overcome this problem, the logarithm of each pixel is first calculated. A subtraction of two images, each in the logarithmic domain, is functionally equivalent to a division outside the logarithmic domain. In the example given above, $\log(100\%)-\log(90\%)=\log(10\%)-\log(9\%)$.

The method of FIG. **4** receives a visible image **402** containing a defect **404**, and an infrared image **406** of the same film with the defect **408**. For reasons explained above, the logarithm is taken of the data in each pixel in the images to produce the log visible image **410** and the log infrared image **412**. Further processing is then performed on small overlapping blocks of the images, such as block **416**, enlarged as block **418** to show vertical strands of hair **420** and the horizontal scratch **422**. Similarly, block **428** is enlarged as block **430** to show only the horizontal scratch **432**. Next the visible block **418** and the infrared block **430** undergo a transform operation to yield the transformed visible block **436** and the transformed infrared block **438**. The transform is selected to better isolate the defect scratch **422** from the hair **420**. Although the hair **420** and the scratch **422** overlap each other in the visible block **418**, they have different characteristics that can be used to distinguish them with the properly chosen transform. Such characteristics include angle and frequency. These characteristics are distinguished by several linear transforms, including the discrete cosine transform (DCT), and the discrete Fourier transform (DFT), both well known in the art. The DFT has the best separation of diagonal angles, but the DCT handles boundary conditions better.

In either the DCT or DFT, the vertical hair **420** produces a pattern **440** in transform space that is well separated from the pattern **442** produced by the horizontal scratch **422**. The advantage of operating in transform space is now apparent: there can be more complete removal of the defect pattern **442** with less damage to the image pattern **440** if they have less overlap. This may be analogized to the increased ease with which a weed may be removed the farther it is from a flower.

In practice, the isolation of the resulting image and defect transform patterns will usually be less crisp than in this simple illustration; however, a transform such as the DCT will provide much better isolation than would be seen in the raw image.

Continuing with the related art method, the transformed defect block **438** containing the defect pattern **448** is split into two blocks **450** and **452**, representing together a range between which the defect pattern **442** in the visible transform **436** is expected to lie. In particular, block **450** bounds the defect from below with a lowered defect limit **454**, and block **452** bounds it from above with a raised defect limit **456**. The range between defect limits **454** and **456** provides some "wiggle room" to ensure erasure of the visible defect pattern **442**. Therefore, the infrared defect pattern **448** does not need to perfectly match the visible defect pattern **442** to insure complete defect removal. This "wiggle room" is critical to inexpensive scanners that may not image infrared details precisely the same as visible details. If the range is too small, not all the defect will be removed. If it is too broad, some image detail will be lost along with the defect. The better the transform is at isolating image and defect, the more the range can be expanded to ensure defect erasure without damaging image detail.

Function block **460** subtracts the defect blocks **450** and **452** from the image block **440** to produce the corrected block **462** containing, ideally, only the transformed image component **464**. In particular, function block **460** is a smart subtraction that, for each element in block **436**, will subtract whatever blend of the same matching elements in blocks **450** and **452** will give the smallest magnitude after subtraction. As an example, suppose specific element **470** of the image transform had a value of 10.0; the upper bound element **472** was 4.0; and the lower bound element **474** was 2.0. Obviously, subtracting 10.0−4.0=6.0 produces a smaller magnitude than 10.0−2.0=8.0, and so 6.0 is written into element **476** of the corrected transform image **462**. Algorithmically, a trial subtraction is made of element **470** minus element **472**, and of element **470** minus element **474**. If the two results are of opposite sign, then the result of the smart subtraction **460** is set to zero; otherwise, it is whichever of the two has the smaller magnitude.

Finally, the inverse transform is taken of block **462** to yield corrected image block **480**. This block **480** is placed back into the corrected logarithmic image **482** at block position **484**. The process is repeated with all other, possibly overlapping, blocks in the image to construct the complete corrected logarithmic image **482**. To finish, the antilog is taken of each pixel in image **482** to yield the finished image **486**, similar to the input visible image **402** but without the defects **404**.

SUMMARY OF THE INVENTION

The present invention provides for automatic removal of defects by receiving from a reflection scan of a photograph